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THE

# SCIENCE OF GEOLOGY.

FROM THE GLASGOW TREATISES,

WITH ADDITIONS.

FIRST AMERICAN EDITION.

NEW HAVEN.
PUBLISHED BY B. & W. NOYES.
1838.

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*COMMON SCHOOL TREATISES NO. I.*

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# ADVERTISEMENT

## TO THE FIRST AMERICAN EDITION

The increasing interest with which the science of Geology is regarded by all classes of readers has induced the reprint of this compendium, which forms one of the series of useful little works known as the Glasgow Treatises. Several paragraphs and cuts have been added, for the purpose of illustrating American Geology, or new discoveries in the science. Few alterations have been found necessary in revising the text, but the theory of Mr. Lyell in regard to ancient climate is now stated in a more guarded manner than was adopted by the author; this being, probably, the most doubtful of all the positions maintained by that eminent geologist.

EDITOR.

*New York, July* 30, 1838.

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THE

# SCIENCE OF GEOLOGY.

THERE is no science—not even excepting astronomy—so deeply interesting as geology, whether in a popular or scientifick point of view, and yet there is none so little known. Several causes have contributed to this. For example, many people are apt to confound this science with mineralogy, and so regard it as a dry study of the qualities of rocks. Another, and perhaps a principal cause, is the alleged discordance between its doctrines and the terms of the Mosaic history. We trust to be able to show that there is no such discordance; but, at present, we would simply remark, that nothing can be more absurd than to allow such an *allegation* to prevent us from prosecuting the study of any science. The Bible is given to us, not as a history of the physical changes which have occurred in the history of our globe, but as a revelation of those truths which divine wisdom has considered necessary for our moral guidance and direction. There are statements in the Bible which we cannot explain, and there are thousands of instances in the material world where we are equally at fault. And should it be cause of wonder that we cannot reconcile the appearances of the crust of our earth with the short and condensed history given by Moses? As well might we denounce the study of astronomy, because we are told, in the history of Joshua, that the sun



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"stood still"—and thus imitate those who cast Galileo into the dungeons of the Inquisition for having discovered the motion of the earth. If the Christian religion be true, it will be illustrated and confirmed by every new discovery in physicks. Such has been the case with every science, and it must be the same with geology.

In a little treatise like this, it will of course be impossible to enter into all the technical and scientifick details involved in the subject. Such is not our object. We propose simply to give a popular account of some of the more interesting phenomena of which geology treats, and then notice those doctrines to which recent discussions have given prominence.

---

## CLASSIFICATION OF ROCKS.

The rocks which compose the crust of our earth may be arranged under two general divisions—the unstratified and the stratified. The former are of igneous origin, and are destitute of organick remains. The latter are disposed in beds or strata, are of aqueous origin, and (except the primary rocks,) contain the fossil remains of plants and animals.

### UNSTRATIFIED ROCKS.

The igneous or unstratified rocks form an extensive group, in which granite and lavas occupy a prominent part. Porphyry, diallage, pitch-stone, basalt, scoria, and the trap-rocks, belong to the same series. All these substances possess evidences of a common origin, and they all exhibit the same geological phenomena. Unlike the stratified, however, we have no means of judging of the relative antiquity of igneous rocks, for we find them associated

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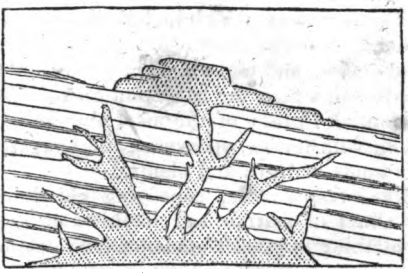
with strata of all characters, and of all ages. Sometimes they appear at the very surface, and at others they are only found at great depths. At the same time there are certain rules by which we may ascertain, in special circumstances, their relative antiquity, as compared with adjacent rocks. For example, if we find a mass of granite penetrating a particular stratum, breaking it up, and branching through it in veins, we must conclude, that here the granite is the more recent of the two; that is, that it assumed its present position subsequently to the formation of the stratum which it traverses.



The above figure represents granitick veins, branching through stratified rocks, and overlying them at the surface. The proofs of the igneous origin of the unstratified rocks is very complete. Not only does their structure establish it, but we find that wherever they have been erupted into or through the stratified rocks, the texture of the latter, at the point of contact, exhibits the marks of the action of intense heat. Thus, wherever the slate-rocks are intersected by granitick veins, they assume the appearance of mica-slate or hornblende; beds of shale and sandstone are reduced to jasper; and compact

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limestone and chalk are converted into crystalline marble.

### STRATIFIED ROCKS.

These have been classed under the following divisions:

1. *The primary*, consisting of gneiss, quartz, hornblende, &c., but containing no organick remains.

2. *The transition*, presenting alternations of slate and shale, with slaty sandstone, limestone, and conglomerate rocks, and containing remains of fishes, shells, and vegetables. The coal-formation belongs to this division.

3. *The secondary*, which include the lias and oolite formations, various limestones, variegated sandstone, conglomerates, and others. They are richer in organick remains than the transition-rocks. We here find gigantick lizards of the most extraordinary description, with turtles, opossums, and kangaroos, and various kinds of trees and plants.

4. *The tertiary rocks*, consisting chiefly of alternating strata of marine and fresh-water deposites, and containing in great abundance the remains of animals and plants, approaching in genus or species to those which at present inhabit our continents and seas.

The igneous and primary rocks constitute, mainly, the hills of New England, and the mountain-group in the northern part of New York; also, the Blue ridge and its collateral elevations, extending southwesterly through the Atlantick states.

The transition and secondary rocks, but chiefly the former, constitute the greatest portion of the interiour of the United States, west of New England.

The tertiary deposites constitute a large portion of the shores and low country of the states south of New England, and bordering on the Gulf of Mexico.

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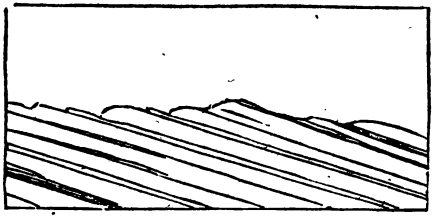
## ARRANGEMENT OF STRATA.

It was one of the many absurd doctrines taught by Werner, that strata were arranged in beds parallel to the horizon, and that they succeeded each other in regular coatings round the world, like the peelings of an onion. This is not the case. They are generally inclined at greater or less angles to the horizon, and their ends or edges *crop out* at the surface from under each other, in this manner:



Were the arrangement otherwise, we would have remained for ever in ignorance of many of the lower rocks, because we could only have reached them by cutting through enormous superincumbent masses of impenetrable thickness. Coal, for example, would have been unknown to us, and also the metals in which the inferiour strata abound. But in consequence of the admirable arrangement of nature, we obtain easy access to all the different rocks, and, what is of equal importance, we find them not all together, but distributed in different districts. As we walk over a country, we come perhaps upon the *out-crop* of primitive rocks; and here, though dreary and barren, the country is wild and romantick, and affords valuable minerals. We advance upon more recent formations, where we have no minerals, but where we find a district rich in ag-

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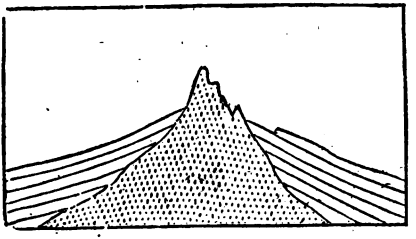
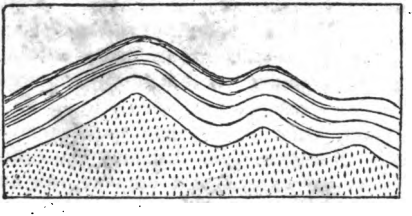
ricultural produce. Farther on, it may be we come to strata abounding in coal, and affording scope for the exercise of manufacturing industry.

Strata are not only elevated at an angle, but we often find them twisted and contorted in various forms, according as they have been acted upon by the igneous agents which disturbed their original tranquillity. Sometimes they are broken in the middle by the eruption of an igneous rock, and lie on either side of the intruded mass, thus:



In other instances, where the strata are more elastick, they assmue a contorted form, in this manner:



## AGE OF ROCKS.

The relative antiquity of stratified rocks is determined by their order of superposition, and by the

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organick remains of animals and plants imbedded in them. Thus, the aqueous deposites of the present period, those which we see forming under our own eyes, and which inclose the remains of vegetables scarcely altered, and of animals still living on the surface of the globe, are the uppermost of all the others. Immediately below these comes the diluvium, of the nature of which little is known. Continuing to descend, we meet with rocks, the remains inclosed in which, differ more and more from those of our day. At last we arrive at the crystalline stratified rocks, the mica-slate, and the gneiss, in which no traces of organick remains have yet been discovered, and which are hence called *primary*. Thus in stratified groups, the oldest of two rocks is always that which is lowest.* These different groups again are subdivided into formations; and, independently of superposition, we judge of their relative ages, and of the length of time which must have elapsed between them, by the fossils peculiar to each. To take the tertiary rocks for example. This series has been arranged under four chronological divisions. In the oldest, out of twelve hundred shells found in the strata, not fifty belong to existing species. In the second, out of one thousand, we have about one hundred and seventy still surviving. In the next, from a half to a third of the shells now exist; and in the fourth, or most recent, almost all the imbedded shells belong to species still living in our seas. In Sicily, portions of the last-mentioned, or *newest* formation, rise to the height of two thousand feet, and contain shells and corals which are at present found in the Mediterranean.

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* M. Rozet, Traité Elémentaire de Géologie. p. 152.

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### PEAT.

Of recent formations peat is one of the most curious. It is a substance derived from the matter of decomposed vegetables, and is, in all probability, the origin of coal. It generally forms a stratum on the alluvial soil, but in some cases it alternates with sand, gravel, clay, or beds of shells; thus forming the rudiments of future coal-strata. Peat can only be formed under a particular temperature, and moisture is essential to it. In hot climates it can only be formed under water, or in elevated places, for otherwise the decomposition of vegetable matter would be too rapid. But in cold climates it may be formed at the level of the sea. In England, it is principally formed from a species of moss, growing in damp situations. Forests which have been overthrown by storms—and instances of such have been frequent—often contribute to form peat. The decay of the leaves and small branches commences the process, and the interstices are gradually filled up, until the trunks are enclosed and covered. Hence the frequent occurrence of the remains of trees, both in the peat and coal-formations. These trees are sometimes so numerous as to form, in fact, fossil forests. In the valley of the Somme, a mass of peat reposes on an immense quantity of the branches and trunks of dicotyledonous trees heaped on each other, and resting on clay. On the borders of the Rhine there exist similar masses, in which the trunks are so flattened, that trees of a foot in diameter present a thickness of only two inches.*

### COAL.

Of the *vegetable* origin of this most valuable mineral, there can be no question. Its whole appear-

* M. Rozet, p. 193.

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ance, the numerous remains of plants which it incloses, and the large quantity of carburetted hydrogen which it gives forth, leave no doubt on this point. We may suppose that islands of greater or less extent were covered with a vigorous and luxuriant vegetation—the united effects of heat and moisture; that these, by their decomposition, produced beds of peat, of various extent and thickness, in valleys which opened toward the sea; and that these beds had been subjected to great pressure—perhaps by submergence under the ocean—by means of which, aided, probably, by some degree of heat, they were converted into coal. The coal-formation is common to countries the most opposite, at present, in point of temperature. It occurs in India and in England, in America and in New Holland, in Greenland and in Chili. The fossil flora which it contains is rich beyond all conception. Of ferns alone, no less than a hundred and twenty species have been already discovered in it, most of them extinct.

The coal-formation consists of beds alternating with strata of what is called *shale*, and of ironstone and sandstone, in irregular succession, and varying in almost every section. These strata are generally inclined, and often at a very high angle, and *unconformable*, that is, not parallel, to the strata above them. A curious peculiarity of the coal, and one which in Europe, greatly assists in working it, is the *faults* which constantly occur in the beds. These are caused by fissures traversing the strata, extending often for miles, and penetrating to a depth in very few instances ascertained. They are accompanied by a subsidence of the strata on one side, or an elevation on the other, and sometimes by both. These breaks or dislocations have been caused by violent mechanical convulsions, subsequent to the original



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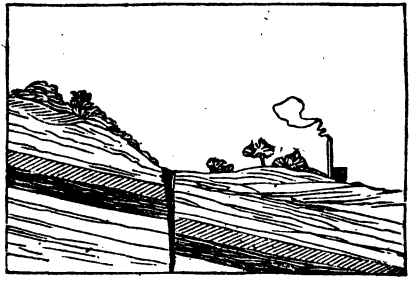
formation of the strata; and as the change of level sometimes exceeds five hundred feet in perpendicular height, the power which could move upward such enormous masses, must have been very great. That that power was volcanick there can be but one opinion. The rents or fissures are usually filled up with clay. Some idea of these *faults* may be formed from the subjoined cut.

Had these beds of shale and sandstone, which alternate with the coal, been continuously united without fracture, the quantity of water that would



have penetrated from above, into any considerable excavation made in the porous beds, would have been insuperable; whereas, by the occurrence of a series of faults, such as I have described, the component strata of a coal-field are divided into numerous isolated masses, each separated from its next adjacent mass by a wall of clay, through which the water cannot penetrate, and thus each mass or seam is wrought separately, and with ease.

Some modern writers—well-meaning men, but wofully ignorant of geology—have averred that the sin of our first parents was followed by great natural convulsions; and they appeal to the dislocation of

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stratified masses in proof of this.* To say nothing of the date of these dislocations, (which, in regard to many of them, must have been long anteriour to the time when man came upon the earth,) it is a sufficient answer to such a hypothesis, that the dislocations in question (as we have seen,) are of the most essential benefit to us. Similar convulsions caused the present inclined position of all strata, for originally they were deposited horizontally; and thus, so far from such convulsions being a curse, the earth but for them would have been uninhabitable.

### SANDSTONE.

Various extensive formations of sandstone exist in all the series of the stratified rocks. It has been produced by the decomposition of older rocks, of which evidence is exhibited in its structure. The old red sandstone, for example, is constituted of quartz, felspar, and mica. In the more recent sandstone, fossil remains of trees and plants are very common. The interiour of the plant is usually filled up with the sand, while the bark is converted into coal. Shells, encrinites, and other fossils, are also found in this formation.

The new red sandstone constitutes a formation of some extent in the eastern part of New Jersey, and on the western border of the Hudson, below the highlands. Also, in the valley of the Connecticut resting on the primitive, from near the line of Vermont to the borders of the Sound, near New Haven. Fossil fishes are found in this formation, in layers of shale, which are interstratified with the sandstone.

### LIMESTONE.

The more recent limestone has been formed,

* See Dick's Christian Philosophy, &c.

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partly from the secretions of shells and corallines, and partly from the decomposition of the ancient limestone rocks. Whence the primary limestone was derived is yet unascertained; but some geologists are of opinion, that it has *all* been formed from corals and shells, or other marine exuviæ. The whole formation composes nearly one-eighth part of the superficial crust of the globe, and it appears to have been formed both in fresh water, and in the sea. We have instances of its occurrence at the present day, of which the lake of Bakie, in Forfarshire, in Scotland is an interesting example. Magnesian or conglomerate limestone differs from the common limestone, in that it contains a large proportion of magnesia, and is of a granular sandy structure. The mountain-limestone contains many crevices, cavities more or less deep, and vast caverns, (hung with stalactites) some of which contain the bones of extinct animals.

### CORAL REEFS.

These are among the most interesting phenomena in geology. When we view the enormous masses of which they consist, forming reefs in the ocean, of hundreds of miles in extent, and rising into extensive islands, and consider that all this is the work of an animal so insignificant as to be hardly discernible, we are lost in wonder and admiration. The way in which the corals work is curious. The windward side of the structure, which is exposed to the break of the sea, rises vertically like a wall; while to the leeward, it shelves away. This enables them to work with facility, for they are thus protected from the violence of the waves, which would otherwise impede or destroy them. There are two kinds of these animals distinguished by M. Lesson. One, which he calls *zoophytes saxigènes*,

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are employed in the construction of the exteriour walls. The other, the *saxigènes delicats*, are protected by the first, and never work except in shallow basins, where the water is warm. The coral-formations, though extensive, are not of great height. Some have supposed that these animals build from the bottom of the sea, but this is nonsense. They begin their work on rocks or banks already near the surface; and, in fact, the reefs of the Indian ocean rarely exceed three hundred feet in height.

The first appearance of the reef, above the surface, consists of detached rocks or little islands, forming a sort of chain, which gradually becomes joined, until a circular basin is formed. This basin is at last contracted by additional works, till finally, all communication with the sea is cut off; and then, as the rain gradually freshens the water, the animals die. These masses of rock are frequently elevated to a considerable height above the surface of the ocean, by volcanick action, and thus become islands; while the basins just described, being filled with rain, form lakes affording a supply of fresh water to the future inhabitants. The action of water, and of the atmosphere, in course of time, decomposes the more exposed portion of the rock, and forms an alluvial soil. Seeds of plants float toward it, or are carried by the wind, and light there, and form a vegetation. Birds resort to it. The eggs of various insects, and other oviparous animals, are conveyed to it, in the same way as seeds. Thus the soil comes to be inhabited; and man at last comes, and forms a settlement. Such is the history of islands generally. Raised at first above the ocean, bare and barren rocks, they become gradually clothed with the luxuriance of vegetation, and form the receptacles of animal life. Some coral islands rise to the height of three hundred feet above the level of he sea, and extend many miles in length.



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Remains of coral are found in the interiour of New York and other states, west of the Alleganies; certain varieties of which are sometimes known among the inhabitants by the name of petrified wasps-nests and honey-comb.

### CHALK.

This formation appears to have been entirely composed of the accumulation of marine shells, which have been gradually consolidated, with little intermixture of foreign matter. The finest is nearly of a pure white, and that found near Paris yields about ninety-eight per cent. of carbonate of lime. One of the most characteristick circumstances attending the chalk, is the occurrence of flints, which are constantly present in the upper beds, and often in large quantities. They occur but rarely in the lower. The chalk contains a certain quantity of silex, and at the period of its formation, a considerable quantity of this substance appears to have been precipitated along with it, but still containing water. Hence it may have united into masses, especially where organick remains were present, and thus produced the flints which often retain the form of sponges, &c. The theory of flints, however, is not without much difficulty.

In Scotland, no chalk at present exists; but the occurrence of flints in considerable quantities, in Aberdeenshire and other places, affords unequivocal evidence of the former presence of cretaceous strata, now disintegrated. The soft chalk has been exposed to the action of rain and storms, and has been gradually washed away, while the flints which were imbedded in it still remain. The chalk is extremely rich in organick remains of shells, starfish, sponges, fishes, and lizards. There are also several aquatick plants.

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No chalk has yet been found upon the American continent.

### ROCK-SALT.

No satisfactory theory has yet been advanced to account for the occurrence of this extensive formation. Some have maintained that it was produced from the ocean, but in what way they do not explain; and it is difficult to suppose how it could have been so, for salt water contains many ingredients not found in this rock. The strata above it contain organick remains, as do also those below, but of a different kind. The salt contains none. From this, some have inferred, that the formation took place during the epoch which elapsed between the destruction of one creation, and the calling of another into existence. In point of fact, however, this is one of those matters in regard to which geologists can only theorise. There can, however, be only one opinion as to the importance of the formation, and of the evidence which it affords of the wisdom and goodness of the Creator; for it is essential to the existence of the inhabitants of numerous inland countries, whose access to the sea is difficult or impracticable. Rock-salt in Europe, belongs to the secondary series.

### DILUVIUM.

Those superficial beds of gravel, clay and sand, which we find on the surface of the upper strata, have been termed, by some geologists, diluvium, or diluvial detritus. The beds are not usually stratified, and they contain immense numbers of rolled and rounded stones, many of them of great size and weight. It is obvious that these stones do not belong to the subjacent strata, for they differ from it in composition and structure; and indeed, comprehend specimens

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from almost all kinds of rocks, stratified and unstratified. We may often pick out of the soil, in one field, within a space of a few yards, twenty or thirty different specimens, including trap-rocks, granites of various kinds, mica-slate, sandstone, ironstone, and many others. The question then is, How came they there? It is obvious that they have been transported by currents, for the edges have been rubbed off, and the whole mass rounded, just as we would expect to find stones and gravel, which had been for a long time subject to the action of running water. Several geologists have ascribed them to the deluge; but this is a very unsatisfactory theory, for the waters of the deluge were too short a time upon the earth to produce such extensive effects. Water has apparently been instrumental in transporting and accumulating the materials. But their deposition in the situations where we find them, has probably been the work of various successive periods; and other causes must also be referred to, in order to account for this singular phenomenon. It is just another of those phenomena, as to which geologists are not in possession of sufficient facts to enable them to form a definite or satisfactory theory.

Alluvial soil has sometimes been confounded with diluvium; but, properly speaking, the term alluvium belongs to a more recent formation. The matter carried down by rains and floods, and which we see deposited every day in lakes or estuaries, or added to the banks of rivers, is alluvium.

Such are a few of the more interesting formations.

## ERRATICK BLOCKS.

By this term are denominated those blocks of solid rock, some of them of enormous size, and sel-

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dom rounded, which are scattered over the plains in many countries, and also elevated on the sides of mountains. On the eastern side of Jura, for example, where that chain of mountains is separated from the Alps by the long and broad valley of the Aar, we find large blocks of granite, often thirty feet in length, and twenty in thickness, lying at an elevation of more than fifteen hundred feet above the valley. That these blocks came from the opposite Alps is extremely probable, for the mountains of the Jura are not granitick, but calcareous. How they came there it is very difficult to say. Some have supposed that they had rolled down from the Alps, previous to the elevation of the Jura mountains, and had been carried up along with the strata of which the latter are composed. M. De Luc thought, on the other hand, that they had been elevated into the air by the convulsion which elevated the Alpine range, and in their descent had fallen on the opposite mountains. A third set of theorists contend that they have been transported on rafts of ice during some immense flood.

Similar blocks of granite have also been found in Iceland, which is itself entirely formed of lava. These, apparently, must have come from Scandinavia. In the north of Germany, erratick blocks of limestone are found, containing fossils of a kind which do not occur in that locality; and hence these also must have been transported from Scandinavia, across the Baltick. In the same way granitick blocks are found in Lamlash, possessing the peculiar characteristicks of the granite in the neighbouring island of Arran.

These erratick masses abound in most northern countries, and when traced to their parent rocks, are generally proved to have been transported in a southerly direction, both in Europe and America. Blocks

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and boulders from the rocks west of Lake Champlain, are scattered over the high grounds in the central and southern parts of New York, and similar observations have been made in New England and the western states. The direction of transfer in these cases being found to correspond generally with the direction of the polar currents of the ocean, it has been inferred that many of these masses have been transported in fields of ice or floating icebergs, at a period when the fossiliferous rocks of this country were beneath the ocean, in the same manner that blocks, boulders, and diluvium are brought to the banks of Newfoundland in the ice, at the present day.

## FOSSIL REMAINS.

Before proceeding to consider the causes which are at present operating changes on the earth's surface, it may be proper to notice briefly the very interesting and extraordinary fossil remains of animals and plants, which are found imbedded in the stratified rocks. No department of geology is so attractive as this. It carries us back to ages far remote. It introduces us to islands and continents subsequently buried for ages beneath the ocean; and it brings vividly before us races of animals and plants long extinct, many of them of the most singular conformations, and of gigantick proportions. "When we see," says Dr. Buckland, "the body of an ichthyosaurus, still containing the food it had eaten just before its death, and its ribs still surrounding the remains of fishes that were swallowed ten thousand, or more than ten times ten thousand years ago; all these vast intervals seem annihilated; time altogether disappears; and we are almost brought into as immediate contact with events of immeasurably distant periods, as with the affairs of yesterday."

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As we distinguish great epochs of change in the arrangement of strata, so we find corresponding changes in the species, and even in the genera, imbedded in them. The shells of the ancient strata, for example, have forms peculiar to themselves. Then these gradually disappear, till they are not seen at all in the recent rocks, still less in the existing seas; in which, indeed, we never discover their corresponding species, and of some of them not even the genera. On the contrary, the shells of the recent era resemble, as respects the genus, those which still exist in the sea; and in the last formed and loosest strata, there occur species identical with those which at present inhabit the ocean.* The same holds in regard to other animals. In the transition rocks, we find fishes, sponges, &c., but no quadrupeds. In the secondary formations, along with fishes, zoophytes, and crustacea, we find various oviparous quadrupeds. Such are the crocodiles of Honfleur, and of England, and the monitors of Thuringia. We also find various species of iguanodons or lizards, pterodactyles, tortoises, and other reptiles, and also insects. The birds and land-quadrupeds do not appear till long afterward, being first found in the tertiary strata, which, as we have already had occasion to remark, are the most rich in organick remains. In this series we find quails, owls, buzzards, and other birds; tortoises and crocodiles, bats, squirrels, opossums, the anaplotherium, palæotherium, and other curious extinct animals; with various moluscans, and mammiferous marine animals. The remains of carnivorous and ruminating animals, and of pachydermata, are particularly abundant. Most of these are extinct, being entirely different

* Cuvier—Theory of the Earth, p. 13.

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from all existing species. The plants of the different epochs are equally curious as the animals.

It is chiefly owing to the investigations of the great Cuvier, that geology is indebted for the knowledge of fossil remains. By a scientifick, but beautifully simple process, he was enabled, from the inspection of almost a single bone, to reconstruct the entire animal. After stating the necessary peculiarities of the different parts of the body of carnivorous animals, M. Cuvier thus concludes his interesting deductions:—"In short, the shape and structure of the teeth regulate the forms of the condyle, of the shoulder-blade, and of the claws, in the same manner as the equation of a curve regulates all its other proportions. And as in regard to any particular curve, all its properties may be ascertained by assuming each separate property as the foundation of a particular equation, in the same manner a claw, a shoulder-blade, or condyle, a leg, or arm-bone, or any other bone, separately considered, enables us to discover the description of teeth to which they have belonged; and so also reciprocally we may determine the forms of the other bones from the teeth. Thus commencing our investigation by a careful survey of any one bone by itself, a person who is sufficiently master of the laws of organick structure may, as it were, reconstruct the whole animal to which that bone belonged."*

We shall now describe very briefly a few of the more remarkable of the extinct animals, though indeed selection is difficult, where all is interesting.

### THE DINOTHERIUM.

This extraordinary animal is the largest of all the terrestrial mammalia yet discovered, being of the

* Theory of the Earth, p. 94.

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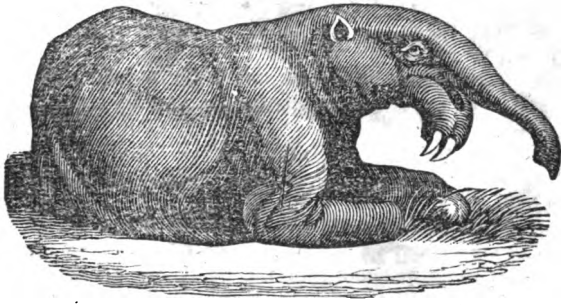
enormous length of eighteen feet. It was a herbivorous animal, holding an intermediate place between the tapir and the mastodon, and inhabited fresh-water lakes and rivers, feeding on herbs, and aquatick



[The Dinotherium restored.]

roots, and vegetables. Its lower jaws measure four feet in length, and are terminated at the extremity by two large tusks curving downward, like those of the upper jaw of the walrus, by which it seems to have hooked itself to the bank as it slept in the water. The remains of the dinotherium are found in tertiary limestone formations.

### THE MEGATHERIUM.

This monster belonged to the sloth species, but it exceeds the largest rhinoceros in bulk. It seems to have had a bony coat of armour for its hide, similar to that of the armadillo, and about an inch in thickness. Its haunches were more than five feet wide, and its body was twelve feet long, and eight feet high. Its feet were enormous, being a yard in length, and more than twelve inches wide, and terminated by gigantick claws; while its tail, which probably served as a means of defence, was larger



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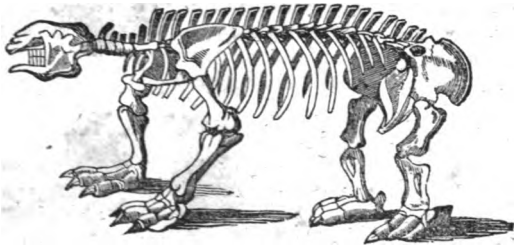
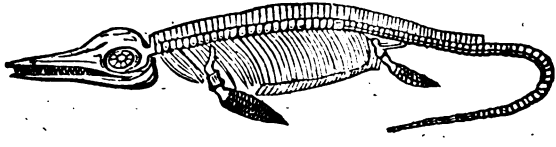


[The Megatherium.]

than that of any other beast among mammalia, whether living or extinct. From the appearance of the anteriour part of the muzzle, it must have had a short trunk or snout like the tapir, for gathering up the roots, which it dug from the ground, or from the bottoms of rivers, with its powerful feet and claws. The remains from which Cuvier derived a knowledge of these facts, were discovered in alluvial soil in the sandy plains of the Pampas of Buenos Ayres. They are found along with fossil remains of the mastodon.



THE ICHTHYOSAURUS.

This name literally means *fish-lizard*. The ichthyosaurus belongs to the family of saurians, but with the vertebræ of a fish it partakes partly of the character of the crocodile, and is otherwise of a description of which existing reptiles of the lizard-kind can afford us no idea. It resembled the modern

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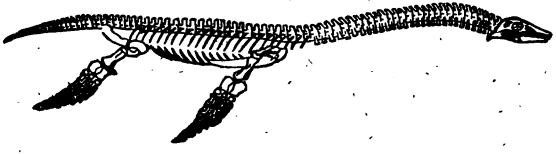
porpoise, but had four broad feet or paddles, like those of the whale, and was terminated behind by a long and powerful tail. Some of the largest of these animals must have been upward of thirty feet in length. One of their most extraordinary features is the eye, which in diameter is found as large as fourteen inches, and must have possessed great powers of vision. The expansion of their jaws too must have been very great, the length sometimes exceeding six feet. The ichthyosaurus was an aquatick carnivorous animal, but breathing air. Its remains have been found containing the scales, bones, and teeth of various fishes, and even fragments of the bones of small ichthyosauri; so that those monsters of the ancient world devoured even their own young.* It is found in the secondary series of geological formations.



THE PLESIOSAURUS.

The characters of this animal have been described by Cuvier, as altogether the most numerous that have yet been found amid the ruins of a former world. It had the head of a lizard, the teeth of a crocodile, a trunk and tail of the proportions of an ordinary quadruped, the ribs of a chameleon, the fins or paddles of a whale, while the neck was of enormous length, resembling a serpent attached to the body. This neck it probably darted suddenly upward, and caught birds or insects which happened

* Rozet, p. 395.

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to come within its reach, and it may also have used it for catching fish in the water below it. It was evidently an aquatick animal. It is found in the same strata as the ichthyosaurus.

### THE PTERODACTYLE.

This very curious and anomalous reptile possesses a head and neck resembling that of a bird, wings like those of a bat, and the body of a lizard. It is neither a bird nor a bat, however, but belongs to an extinct genus of the order of saurians, which by a peculiarity of structure were enabled to fly in the air. Eight species of these animals have been discovered, varying from the size of a snipe to that of a cormorant, and in external form resembling our bats. Besides the power of flying, they were enabled to swim like other amphibious lizards, and in all likelihood they fed not only on insects but on fishes.

THE IGUANODON.

This animal is of a more gigantick race than any other of the lizard tribe, some of them having attained the enormous dimensions of seventy feet in length, measuring from the snout to the extremity of

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the tail, and of fourteen feet round the body. The most credulous would be apt to reject the account of such a monster, as beyond even the privileged limits of fable, were not the evidences of its existence, derived from its fossil remains, of a character so clear and unequivocal. It appears to have lived upon vegetables, and is found in what is called the Wealden formation, in the secondary rocks of the south of England. The largest of the living iguanodons scarcely ever exceed five feet in length.

Besides these amphibious and land animals, there are remains found of many curious saurian fishes, some of them attaining a great size, and of a description altogether different from any existing genus.

### THE MAMMOTH.

This animal, though extinct, belongs to a period much more recent than any which we have mentioned. It is of the elephant kind, and its remains are found in England, Scotland, and other countries; but nowhere are they so abundant as in Siberia, where the tusks form an article of commerce by the natives. The entire carcase of a mammoth was not long ago discovered imbedded in the ice, where it must have remained for ages. So complete was the state of preservation in which it was found, (owing to the coldness of the climate,) that the flesh was eaten by dogs. The bones of several species of the rhinoceros are found along with those of the mammoth.

### THE MASTODON.

This is a brute much larger than the mammoth, but resembles it in its habits, and belongs to the same epoch. The mastodon is interesting, not only on account of the magnitude of some of the species, but also because it was from it that naturalists were



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first convinced that there have been genera and species of animals which no longer exist. Cuvier distinguished six species of this animal. In America the bones of the gigantick mastodon are chiefly found in the vicinity of saline springs, with the remains of stags and buffaloes. It was an herbivorous animal, living on grasses and leaves.

### FOSSIL BIRDS.

The remains of birds are rare in all strata. In the tertiary rocks we find a few species of the woodcock, quail, cormorant, owl, buzzard, and some others; but few in the older deposites. Although the remains, however, are wanting, we have evidence, from the marks of footsteps in sandstone rocks, of the existence of various unknown birds, some of which must have been of gigantick proportions. The most interesting of those yet discovered occur in the new red sandstone, in the valley of the Connecticut, among which are the footsteps of a bird twice as large as the ostrich. The marks have been caused by a foot consisting of three broad and thick toes, and measuring no less than fifteen inches, or seventeen including the claws; and are apparently those of a bird resembling in character the modern *grallæ* or waders. The footsteps appear in regular succession, in the continuous track of an animal in the act of walking or running, and occur at intervals, varying from four to six feet. This immense length of step is greater in proportion than that of any existing species of birds; and taking the marks at the minimum of four feet asunder, they probably indicate a leg of at least six feet long. If to this we add the body, neck, and head, we have a bird, which could not have been less than twelve feet high, and perhaps more. The African ostrich attains the height of nine feet, while its leg is only

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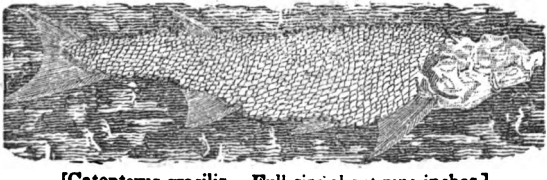
four feet long, and the foot only ten inches. Few traces of any bones but those of fishes, have been found in the rocks containing the footsteps in question; but many tracks of different individuals, and also of different species are found crossing each other. On every track the length of step increases with the size of the foot.* They are called by geologists *Ornithicnites.*

### FOSSIL FISHES.

The remains of fishes are found in all the strata from the lowest secondary to the latest tertiary rocks. In some formations the skeleton alone is found, in others the exteriour scaly covering is beautifully preserved, while no traces of the bones are left. Prof. Agassiz of Neufchâtel, was the first to notice the curious fact, that the fossil fishes of the older formation differ remarkably in their organization from existing species, and even from those found in more recent formations. This difference mainly consists in the prolongation of the vertebræ into the upper lobe of the tail which is always more or less forked. As we proceed from the lower strata upward, this peculiarity gradually disappears, and in the upper secondary and the tertiary rocks it is entirely wanting. In the United States, fossil fishes have been found in the sandstone formation of Con-



[Catopterus gracilis. Full size about nine inches.]

* Professor Hitchcock.

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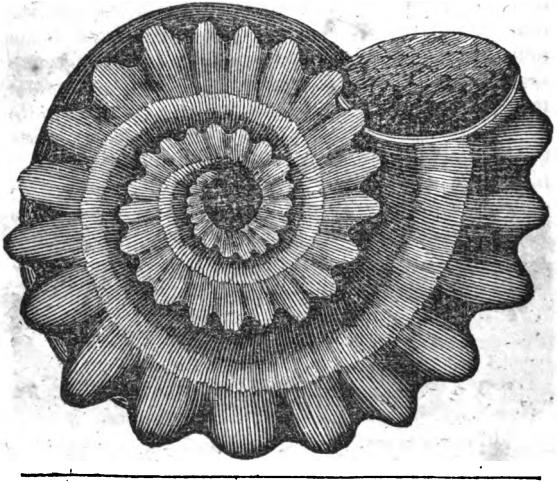
necticut, to which we have already alluded. We give (p. 31) a reduced figure of the *Catopterus gracilis*, a beautiful species which occurs in that formation.*

The secondary and tertiary strata which border the seacoast from New Jersey southward, often furnish the teeth and scattered vertebræ of sharks, with other marine remains. We learn too that fossil fishes have recently been found in the Virginia coal-basin near Richmond, in rocks of the sandstone formation, two hundred feet below the surface.

### FOSSIL SHELLS.

Shells occur in great abundance and variety in many different strata, some of them very large, and others as much the reverse. So minute are some of the species that Saldani collected, from less than an



* Annals of the New York Lyceum of Natural History, vol. iv.

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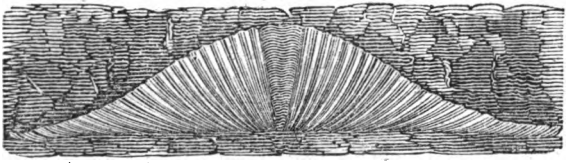
ounce and a half of stone, upward of *ten thousand* chambered shells. Of some species, four or five hundred weigh but a single grain.

Extinct chambered shells, analogous to the *Nautilus Pompilius*, occur in the transition and secondary strata, in prodigious numbers, and some of them of great beauty. These shells are termed Ammonites, and when large, are sometimes erroneously taken for petrified snakes. The peculiarity of this shell as well as of the Nautilus, consists in its being divided into chambers by transverse partitions. Through these chambers runs a tube called the *siphunculus*, which the animal can fill with either air or water at its pleasure, and thus by the change of its specifick gravity ascend to the surface or descend to the lowest depths. The figure (p. 32) is the *Ammonites bellicosus* found by Dr. Hildreth in Ohio.

In the fossiliferous rocks of the transition series, west of the Hudson, there is an extensive stratum which abounds with the impressions of a fossil bivalve shell which is remarkable for its lateral extension on the hinge line: a figure of this shell is here subjoined. This species is not known to have been described; and is probably a *Productus* or *Delthyris*.



But our limits render it impossible to pursue farther this most interesting subject; although the fossil remains of insects, radiated animals or zoophytes, and others, are all equally curious as those which we have mentioned. The various genera of

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extinct plants, likewise present a wide and highly interesting field, whether for study or amusement. Among these we find plants of the genus lipidodendron, forty-five feet long, the living analogies of which are weak and creeping plants, not three feet in height; sigillaria (supposed to have been allied to arborescent ferns,) of fifty and sixty feet high; and stigmaria, (an aquatick plant,) of still more enormous dimensions. An exceedingly interesting account of these and other remains of the antediluvian world, will be found in the Bridgewater treatise of Dr. Buckland, lately published.

Before leaving this subject, we would advert to a very common, but very mistaken notion, entertained by many good people, namely, that previous to the fall of man, animals of all kinds lived together in a state of harmony, no one preying upon or destroying another; in short, that "the wolf dwelt with the lamb, and the leopard lay down with the kid." But nothing is more certain than that races of carnivorous animals have existed from the very earliest geological eras, and that animals fed upon their fellow-animals, thousands of years before man became an inhabitant of the earth. The most superficial study of the structure of the teeth, and other parts of fossil animals, will convince any one of this; and in a very remote series of rocks we even find the remains of the ichthyosaurus, full of the scales and undigested bones of the fishes on which it preyed. A thousand other instances of the same kind might be adduced. The errour is common with that to which we have already alluded, as to the alleged moral cause of the dislocation and disturbance of stratified masses; but none of the phenomena of geology warrant us in supposing that the fall of our first parents was followed by any change whatever in the physical world.

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## CAUSES WHICH OPERATE CHANGES ON THE EARTH'S SURFACE.

No theory in geology is more confirmed by facts than this, that many successive destructions and renovations have taken place on the surface of our globe. People are apt to think that these changes have been sudden, and some of them undoubtedly were so—as, for example, when an entire renewal took place within a space of six days, as recorded by Moses. But in general we are bound to hold, by the evidence before us, and in the absence of evidence to the contrary, that the causes operating now, operated likewise in effecting the revolutions of which we speak; and it will be found that the existing agents are sufficient to account for most, if not all the phenomena, which we meet with in our investigations.

There are two great antagonist powers in nature —the aqueous and the igneous. The former, as in springs, rivers, tides, frosts, and rain, is constantly employed in the disintegration of rocks, and in the degradation or levelling of land. The latter, by volcanoes and earthquakes, is, on the other hand, employed in restoring the elevation and inequalities of the surface. Were there no such compensating power of elevation, a time would come when the whole materials of the loftiest mountains would be transported to the ocean and when the whole earth would be reduced to a saline marsh. To these effects there are exceptions, for sometimes the igneous agent appears as an instrument in the depression of land, as where subsidences are caused by earthquakes; and on the other hand, the aqueous is often found exercising a reproductive function, as when land is created by the deposites formed by rivers and tides.

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## AQUEOUS CAUSES.

It is well known that land elevated above the level of the ocean, assists in the condensation of a large proportion of the vapour, which the heated atmosphere is continually elevating from the surface of lakes and seas. By this process, all water is first carried to the higher regions, and thence descends again in rills and rivers. These streams are continually wearing away the rocks and soil, and carrying them down to the plains or lakes at their source, in the shape of sand and gravel. A velocity of three inches per second at the bottom of a stream, will tear up fine clay; six inches per second will transport fine sand; twelve inches, fine gravel; and three feet per second, stones as large as an egg. When this rate is increased by floods and torrents, the transporting power is proportionally increased. Sir T. Dick-Lander states, that in 1829, on the Nairn, a fragment of stone, fourteen feet long, was carried by that river two hundred yards; and on the Don, a mass of four or five hundred tuns of stones was forced, by the flood, up an inclined plane rising six feet in eight yards.

Besides its solvent power, water is a powerful agent of decay, by its quality of expansion in freezing. The rain penetrates crevices of rocks, and when it freezes, large masses are torn off and separated. The oxygen in the atmosphere also tends to disintegrate rocks. By these causes combined, it is astonishing how rapidly high lands are levelled, and lakes and estuaries filled up by the earth, gravel, trees, &c., which are carried into them. The Mississippi affords a fine illustration of this. The great plain through which that river flows, is bounded on the east and west by great ranges of mountains. Below the junction of the Ohio, this plain is from

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thirty to fifty miles broad, and after that it increases in breadth to upward of one hundred miles. This is alluvial land, that is, land which in the course of ages has been formed by the *detritus* carried down by the river from the high grounds. The Lake of Geneva is rapidly filling up from the same cause. An ancient town, at the upper end, called Port Vallais, once situated at the water's edge, is now more than a mile and a half inland. The intervening tract, which has been acquired in less than eight centuries, has been formed by the earth and sand carried down by the Rhone. From the northernmost point of the gulf of Trieste, where the Isonzo enters, down to the south of Ravenna, there is a series of accessions of land, of more than one hundred miles in length, which, within the last two thousand years, are known to have increased from two to twenty miles in breadth. The phenomena of the Delta of the Nile are equally striking. Without doubt the whole of Lower Egypt was, at some remote period, a gulf of the sea, which has been filled up and converted into fertile land by the deposites of the river.

Mr. Lyell makes an interesting calculation, of the amount of sediment carried down by the Ganges, from which a faint idea may be formed of the transporting power of rivers. Having ascertained the number of cubick feet of water discharged by the Ganges, per second, he calculates, by the safest data, the proportion of solid matter contained in it; and then states, as the result, that "if a fleet of more than eighty Indiamen, each freighted with about fourteen hundred tons weight of mud, were to sail down the river every hour of every day and night, for four months continuously, it would only transport from the higher country, to the sea, a mass of solid matter equal to that borne down by the



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Ganges in one flood season." In this way has been formed, by the *detritus* carried down from the Himalaya mountains, an extensive portion of the fertile plains of Hindostan.

### EFFECTS OF SPRINGS.

Springs have, likewise, a considerable effect in destroying the rocks and soils through which they pass; and, accordingly, most of them are found impregnated with foreign ingredients. A thermal spring near Clermont, in France, has formed, by its incrustations, an elevated mound of white concretionary limestone, two hundred and forty feet in length, and at its termination sixteen feet thick. At the baths of San Vignone, half a foot of solid limestone is formed every year at the bottom of one of the conduit-pipes. Other springs deposite *silica* or flint—a substance so hard as to excite surprise how it can be held in solution by water at all.

There are also *chalybeate* springs, some of them containing iron in large quantities, which acts as a colouring and cementing principle in the sub-aqueous formations now in progress. And there are *brine-springs*, many of which yield one fourth of their weight in common salt; *carbonick-acid* springs, which decompose the hardest rocks; and *petrolium* springs, yielding bitumen, asphaltum, and pitch, in great abundance.

### EFFECTS OF THE SEA.

By constant attacks on its coasts, the sea is another formidable agent in the disintegration of rocks, and often destroys large tracts of country, forcing its waters into the interiour of continents.

In 1282, a series of violent storms broke up the isthmus which united Friesland with the north of Holland, and formed the Zuyder Zee. In 1475, a

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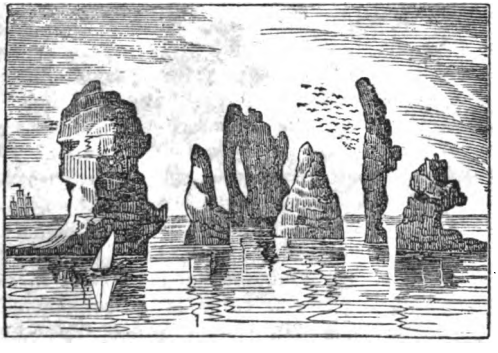
considerable tongue of land, situated at the mouth of the Humber, was carried away by the sea, which destroyed at the same time many villages. In 1510, an irruption of the Baltick formed the opening of Frisch-Hoff, six thousand feet broad, and from twelve to fifteen fathoms deep. In 1625, the sea detached a portion of the peninsula of Dors, in Swedish Pomerania, and formed the island of Zingst. And in 1634, a violent inundation submerged the whole island of Nordstrand; churches, houses, all were destroyed; six thousand four hundred persons perished; and there remained of that fine island only three detached portions, Pelworm, Nordstrand, and Léetje Moor.*

The Shetland isles, exposed to the whole violence of the Atlantick, are in a state of rapid disintegration, by the winds and waves. During winter, rocks, weighing several tons, are often detached and rolled into the sea. Many small islands have thus been destroyed, till nothing but a few pinnacles of rocks remain. The cut below, represents a sin-



* M. Rozet, p. 50.

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gular cluster of such rocks to the south of Hillswick Ness, England. They are the remains of a mass of granite.

Along all the western shores of France, and on the east coast of England, we likewise see evidence of the daily encroachments of the sea. The rate of encroachment at Owthorne in Yorkshire, is reckoned at four yards in every year; and Pennant makes mention of several villages, all which have long since been swallowed up by the ocean. In like manner, the cliffs of Norfolk and Suffolk, and parts of Cornwall, are suffering a constant decay. The ancient villages of Shipden, Wimpwell, and Eccles, besides many extensive estates, and tracts of land, have been gradually engulfed; and all the ancient part of Dunwich has perished. At one time four hundred of the houses in that town were destroyed at once; and subsequently, the churchyard of St. Nicholas was laid open by the waves, and the coffins and skeletons exposed. No remains of this cemetery now exist. There is every reason to believe that England was formerly united to France; and that the separation was effected by the action of the sea upon the cliffs, in the same manner in which we see it still acting upon our own coasts.

But if the sea be so destructive an element, so also is it, like the rivers, an agent in the reproduction of land. The rocks and sand washed away from one place, are carried by tides and currents far into the ocean, where they are deposited in strata, and in course of time form shoals and banks, which afterward become promontories and islands. Marine currents are numerous and tortuous in their course, and, like rivers, carry in suspension abundance of mineral matter, which they deposite at different places. Hence, in inland seas, and even on the borders of the ocean, it is sometimes scarcely possible

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to prevent a harbour from filling up. The Isthmus of Suez has doubled in breadth since the time of Herodotus. Suez, in 1541, received into its harbour the fleet of Solyman II., but it is now changed into a sandbank. Large banks are, in like manner, in the course of formation in the German ocean. One of them runs out from the Frith of Forth, upward of one hundred miles; and others, equally extensive, run from Denmark and Jutland, to the northwest. The whole superficies of these shoals, may be reckoned as equal to a third of the whole island of Great Britain, and they rise to an average height of about seventy-eight feet. Many other examples might be cited. The ruins of ancient Tyre, once on the coast, are now far inland; and those of Sidon are two miles distant from the sea.

In the same way that alluvial land is thus forming, have many of the stratified rocks throughout the world been deposited; and as animals and plants of various descriptions are carried away, and buried among the deposites of rivers, by floods and other casualties, so at some future age will such animals and plants be found imbedded in those newer strata, just as we find organick remains enclosed in the older rocks. The deposition of strata has been the work of incalculable ages; but the process may be traced every day, in the sections of lakes, and marine estuaries. The strata thus formed are consolidated, partly by volcanick heat, partly by chymical substances, and partly by the pressure of the ocean where subsidences have taken place.

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## IGNEOUS CAUSES.

We now turn to a very opposite, but equally powerful cause of change in the earth's surface, namely, the igneous, including volcanoes and earthquakes.



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These two are inseparably connected, being but different results of the same common cause. The volcano may be termed the safety-valve by which those gases or heated matters which cause the earthquake, find vent; for we generally find, that when the volcano breaks forth, the earthquake ceases.

### VOLCANOES.

Volcanoes are not of accidental occurrence, but are at present chiefly confined to particular geographical boundaries. Some volcanick mountains are in a state of constant activity; such as Stromboli, in one of the Lipari isles, which has never ceased during a period of more than two thousand years. In others, the eruptions occur from time to time, at irregular intervals, of which Vesuvius and Etna are examples; and others are extinct, not having been known to be in a state of eruption within the period of authentick history. Of these last there occur instances in Hungary and on the Rhine. Volcanoes at this day, are mostly found near the sea. But this rule is not without exceptions; for Jorullo, a celebrated volcano in the region of the Andes, is situated one hundred and twenty miles from the nearest ocean. The principal volcanick districts in Europe, are those of Etna, Vulcano, Vesuvius, Santorin, and Iceland. An eruption, or earthquake, is generally preceded by certain symptomatick phenomena, such as subterranean noises; the drying up of neighbouring streams; the appearance or increase of smoke above the crater; uneasiness manifested by cattle; reptiles which live under ground, coming out of their holes; and frequently the agitation of the sea.

Before inquiring into the causes of earthquakes and volcanoes, we shall state some prominent instances of their effects.

In snowy regions, such as the Andes, the effects

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of an eruption are terrible; for not only are large masses of lava ejected, but the intense heat melts the snow, and so produces the most destructive inundations, carrying volcanick sand, loose stones, and other materials, into the plains below. Sometimes subterranean cavities, filled with water, are rent open, and increase the flood. Mud and sand derived from such a source, descended in 1797 from the sides of Tunguragua, and filled valleys, a thousand feet wide, to the depth of six hundred feet. It is a very curious circumstance connected with volcanoes, that among the hot water, (which very frequently forms part of the ejected matter,) quantities of small fish are often found, which, according to Humboldt have lived in subterranean lakes and cavities. So great was the quantity of these fish, ejected at one time from the volcano of Imbabura, that the effluvia arising from the putrid animal matter, occasioned fevers in the district. In the interval between eruptions, innumerable hot-springs afford vent to the subterranean heat; and solfataras—that is, vents emitting sulphur, and acid vapours and gases—discharge copious streams of inflammable matter.

Iceland is entirely of volcanick origin, and so intense at times has been the volcanick action in that district, that Mount Hecla has sometimes continued in eruption for six years without ceasing, shaking the whole island, and causing great changes in the surface of the country. Another great volcano in Iceland is Skaptar Jokul. In the year 1783, this mountain, after repeated earthquakes had been felt, burst into eruption, throwing out a torrent of lava, which flowed down into the river Skaptar, and completely dried it up. The channel thus filled lay between high rocks, in many places six hundred feet in depth, and near two hundred in breadth. Not only did the lava fill up this great defile to the brink,

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but it overflowed the adjacent fields to a considerable extent. The burning flood then poured into, and filled up, a deep lake between Skaptardal and Aa; and advancing again, penetrated and melted down some ancient lava, blowing up fragments of the rock to the height of one hundred and fifty feet. After flowing several days, the lava was precipitated down a tremendous cataract, filling a profound abyss, which the great waterfall of Stepafoss had been hollowing out for ages. This did not end its course, for it continued in other directions, carrying ruin and destruction over the country, not only by overflowing the land, but by the inundations which were occasioned by the filling up of the river-courses. Of the two streams of lava which flowed from the mountain in opposite directions, one was *fifty* and the other *forty miles in length.* The breadth varied from seven to fifteen miles, while the ordinary height of both currents was a hundred feet, though in narrow defiles it sometimes amounted to six hundred.

This awful eruption continued *two years*, and a traveller who visited the tract *eleven years afterward*, found columns of smoke still rising from parts of the lava, and several rents filled with hot water. No fewer than twenty villages were destroyed on this occasion, and more than nine thousand of the inhabitants perished.

In 1538, Monte Nuovo, in the bay of Baiæ, in Italy, was thrown up in a day and a night, and remained permanently elevated, the height being four hundred and forty feet above the level of the bay. Its base is about a mile and a half in circumference.

In 1759, Jorullo, in Mexico, was elevated by volcanick power. For a long time the district where it is situated had remained undisturbed, but in June of the year mentioned, hollow sounds of an alarming nature were heard, followed by earthquakes,

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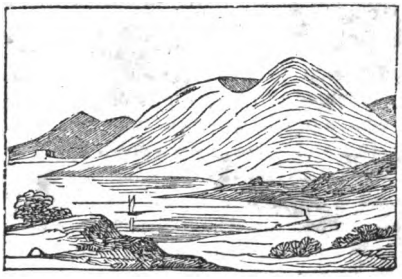

[Mount Nuovo.]

which continued for two months, until, in September, the eruption commenced. Flames issued from the ground; fragments of burning rocks were thrown to prodigious heights; and six volcanick cones were formed, composed of lava and scoria. The least of these cones was three hundred feet in height, and Jorullo, the central one, was elevated one thousand six hundred feet above the level of the plain. Forty years afterward, when Humboldt visited the country, he found the mass of lava still sufficiently hot to light a cigar, at the depth of a few inches! Two small rivers, which had formerly run through the district, disappeared during the eruption, losing themselves below the eastern extremity of the plain, and reappearing, as *hot-springs*, at its western limit.

So great is the expulsive power of eruptions, that Cotopaxi has been known to throw out, to the distance of *nine miles*, masses of rock of a hundred cubick yards in size. In some instances the tops of volcanick mountains fall in during the eruption; and in this way Papandayang in Java was, in 1772, reduced in height from nine thousand to about five thousand feet.

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Volcanoes are not confined to the land, but occur sometimes in the middle of the sea. So recently as 1831, a volcanick island was elevated in the Mediterranean, to the height of more than a hundred feet above the water, at a place where formerly there was a depth of more than one hundred fathoms. In about a year afterward it again sank, so as to be below the level of the sea. In the year 1806, an island of four miles in circumference rose from the sea, among the Aleutian islands north of Kamtschatka. Another extraordinary eruption happened in 1814, in the same archipelago, when an island of considerable size, with a peak three thousand feet high, was upraised; but it again sank down, after standing about a year.

If such extraordinary effects are produced on the surface of the earth, we have every reason to believe that the subterranean changes are still more extensive. "The loftiest volcanick cones," says Mr. Lyell, "must be as insignificant, when contrasted with the products of fire in the nether regions, as are the deposites formed in shallow estuaries, when compared to submarine formations accumulating in the abysses of the ocean." It may also be inferred, that the ejection of such large masses of melted rocks in one place, is very likely to be accompanied by corresponding depressions at others; and accordingly we do find that in volcanick districts, many such subsidences accompany earthquakes and volcanoes.

Some regions are convulsed by earthquakes, without any volcanick eruptions occurring simultaneously in the same district. But we may infer from analogy, that these regions would not be so convulsed, at least to an equal extent, if a free passage were opened for the escape of the subterranean heat. The more the channels by which the heat is

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transmitted to the surface are stopped or impeded, the more violent will be the convulsion.

### EARTHQUAKES.

One striking peculiarity of earthquakes is the extent of country which is often affected by them. The shock of the earthquake of Chili, in 1822, was felt simultaneously throughout a space of twelve hundred miles, from north to south. An earthquake, which occurred lately at Cutch, was felt at Ahmedabad, and also slightly at Poonah, which is four hundred miles farther. And during one of the earthquakes in Calabria, toward the end of the last century, the surface over which the shocks acted so forcibly as to excite terrour and alarm, amounted to five hundred square miles. The shocks also affect the sea as well as the land. The town of Sorcino was destroyed by the waves of the ocean, during an earthquake in 1780. During the earthquake at Lisbon, the swell rose to a greater height than it had ever been known to do from the most violent storms; and at Cadiz, the swell rose to the height of eighty feet, breaking down the mole which joins the town to the continent. The effect of the shocks on vessels at sea, has been described as similar to the shock that is felt when a ship strikes violently upon a sand-bank.

Of the powerful influence of earthquakes in modifying the surface of the land, perhaps as striking an instance as can be adduced is that which occurred on the coast of Chili, in 1822, and to which we have already alluded. When the district around Valparaiso was examined, after the shock, it was found that the whole line of coast, for the distance of above a hundred miles, was raised near four feet above its former level; and the muscles, oysters, and other shell-fish, which were thus

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exposed, were all dead, and exhaling most offensive effluvia. The rise of the inland country was even greater than that upon the coast. The area thus convulsed and permanently altered, is believed to have extended to a hundred thousand square miles.*

In 1812, a violent earthquake occurred in Caraccas. The surface undulated like a boiling liquid; terrifick sounds were heard under ground; and the whole city, with its splendid churches, was in an instant a heap of ruins, under which ten thousand of the inhabitants were buried. Enormous rocks were detached from the mountains, and that of Sylla lost about three hundred and fifty feet of its height, by subsidence. In 1797, the district around the volcano of Tunguragua, in Quito, for forty leagues from north to south, experienced an undulating movement, which lasted four minutes. Every town was levelled to the ground; and Riobamba, Quero, and other places, were buried under masses detached from the mountains. At the foot of Tunguragua the earth was rent open, and streams of water and fetid mud poured out, overflowing and wasting everything. In valleys one thousand feet broad, the water of these floods reached to the height of six hundred feet, barring up the course of the river, and forming immense lakes. The surface of the district thus affected was entirely changed.

The earthquakes which occurred in Calabria present a frightful picture of the desolating power of this tremendous agent; and with a brief notice of these, we shall conclude this branch of the subject.

The shocks began in February, 1783, and lasted for nearly four years. The ground was rent and cracked in all directions. Chasms were formed a mile in length, and hundreds of feet deep. Cities and villages were overthrown, and many houses, and

* Lyell, vol. ii. p. 178.

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even streets, were altogether engulfed. Trees, supported by their trunks, sometimes bent during the shocks to the earth, and touched it with their tops. The quay at Messina was sunk down below the level of the sea; and at Terranuova, a stone well was driven upward out of the earth, so as to form a tower, eight or nine feet in height. Many *land-slips* also occurred. In other words, immense portions of land, sometimes forming the sides of mountains, were separated from the parent mass, and precipitated into the valleys, obstructing the river-courses, and causing lakes and floods. Two portions of land of this kind, about a mile long, and half a mile broad, were carried for a *mile* down a valley; and a thatched cottage, together with large olive and mulberry-trees, most of which remained erect, were carried uninjured to this extraordinary distance. The number of persons who perished during the earthquakes is reckoned at forty thousand; and twenty thousand more died of epidemicks, caused by insufficient nourishment, and by malaria arising from the new stagnant lakes and pools. Many of the victims who were buried in the ruins of the houses might have been rescued, but no person could be procured to remove the superincumbent rubbish. The peasantry either had fled, or had enough to do with their own misfortunes, and neither entreaties nor rewards could induce them to lend the necessary aid. At Terranuova, four monks who had taken refuge in a vaulted sacristy, the arch of which continued to support an immense pile of ruins, made their cries be heard for the space of four days. One only of the brethren of the whole convent was saved, but, unassisted, he could lend them no aid. He heard their voices die away gradually; and when afterward their four corpses were disinterred, they were found clasped in each other's arms.



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[Chasms formed by Earthquakes.]

## ELEVATIONS AND DEPRESSIONS OF LAND, WITHOUT EARTHQUAKES.

As earthquakes sometimes occur, without immediate relation to volcanoes, so there are instances where large tracts of land have been elevated or depressed, by a gradual progressive movement, occasioned not directly by either of these causes, or at least without any apparent evidence of their action, exhibited in the usual manner at the surface. For instance, it has been clearly ascertained that a great part of the coast of Sweden, upon the Baltick, and the Gulf of Bothnia, is slowly but continually rising, and the same phenomenon has been observed upon the western coast of Sweden, particularly near Uddevalla, and the neighbouring coast-land. Into the proofs of this rise, our limits do not permit us to go, but they are clear beyond a doubt. This rising of land in Scandinavia, together with depressions which are known to occur in Greenland and other places, are not improbably connected with subterranean volcanick agency, although the country has been from time immemorial free from volcanoes and violent earthquakes.

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CAUSES OF VOLCANOES AND EARTHQUAKES.

This has been a fruitful subject of dispute among geologists, but as an investigation of all that has been advanced on the subject, would lead us far beyond our present limits, we shall merely take a cursory glance of the more important theories.

The common cause of volcanoes and earthquakes, is on all hands admitted to be connected with the passage of heated matter, which we find ejected from the interiour to the surface of the earth. The question then is, Where does this heat come from? It was the opinion of some very profound geologists, that the earth was originally in a state of igneous fusion, and that as this heated mass began gradually to cool, an exteriour crust was formed, first very thin, and afterward gradually increasing, until it attained its present thickness, which they calculate as amounting to sixty miles. During this process of gradual refrigeration, some portions of the crust cooled more rapidly than others, and the pressure on the interiour igneous mass being unequal, the heated matter, or lava, burst through the thinner parts, and caused high peaked mountains, such as we at present see in the moon. The same cause they allege produces volcanoes still. According to this theory, we live upon a thin crust, enclosing matter in a state of intense heat, which in particular districts agitates the earth in its pressure to escape, thus causing earthquakes; or occasionally bursting forth and producing volcanoes. The arguments adduced for this doctrine are plausible. The first is the form of the earth—that of a spheroid of rotation—being just that form which an igneous *liquid* mass would assume, if thrown into an orbit with a motion similar to that of the earth. Again, they appeal to the fact, that it is found, by experiments in

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mines, that the heat increases with the depth, and that hot-springs and mineral-waters are found in all countries. They likewise argue, that the peculiar appearance of *lavas* all over the world, indicates that they proceed from a common source. And lastly, they contend, that on no other hypothesis can we account for the vigorous growth of sigillaria, arborescent ferns, and other plants found fossil in northern regions—plants which could only have been produced under circumstances of high temperature and moisture—meaning of course that the heat which assisted the growth of this luxuriant flora, must have proceeded, not from above, but from beneath the soil.

This doctrine, nevertheless, is opposed by Mr. Lyell. The spheroidal figure of the earth, he says, may have been caused by the gradual operation of the centrifugal force, acting on the materials brought successively within its action by aqueous and igneous causes. And besides, he adds, it is a gratuitous supposition, that the original figure of our planet was strictly spherical. He maintains moreover, that according to the laws which regulate the circulation of heat through fluid bodies, the crust of the earth, instead of increasing in thickness, would be altogether melted. And finally, he attempts to account satisfactorily, by changes on the surface of the earth, for the growth of the gigantick plants found in cold regions. Mr. Lyell refers the heat of the interiour to chymical changes, constantly going on in the earth's crust; forming particular combinations which evolve heat and electricity, and which again, in their turn, become sources of new chymical changes. He suggests that subterranean electrick currents may exert a slow decomposing power, like that of the voltaick pile, and thus become a constant source of chymical action, and consequent-

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ly of volcanick heat: that the metals of the earth and alkalies may exist in an unoxidized state in the subterranean regions, so that the occasional contact of water with those metals must produce intense heat: that the hydrogen evolved during the process of saturation, may, on coming afterward in contact with the heated metallick oxides, reduce them again to metals: and that this circle of action may be one of the principal means by which internal heat, and the stability of the volcanick energy, are preserved. The sudden fracture of solid strata, by any of the causes mentioned, would produce a vibratory jar, which, being propagated in undulations through a mass of rock several thousand feet thick, (for the crust of the earth is extremely elastick,) would give rise to superficial waves, and so cause earthquakes. Or, as Michell supposes, large districts may rest on fluid lava, which, when disturbed, will produce a similar undulatory motion. And when this pent-up heated matter finds a means of egress, it will rush out, for days or weeks, through the orifice, with an explosive power, accompanied with smoke and flame, and the other peculiarities of volcanick eruptions. The rocks shattered by such subterranean convulsions may assume and retain an arched form; or the gases may drive before them masses of liquid lava, which may thus be injected into newly-opened fissures. In either case, the country above may remain permanently elevated. There is reason to believe that in some such way the mighty Andes have been upheaved from the bottom of the ocean, and indeed most of the present dry land on the face of the globe —for geological phenomena plainly indicate, that each region of the earth has at one time or other been a great theatre of subterranean convulsions.



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## DIFFERENCE BETWEEN THE FORMER AND PRESENT TEMPERATURE OF NORTHERN LATITUDES.

This is a highly interesting topick in geology, and it is one of the most difficult to explain. It is a fact now fully admitted, that the climate of the northern hemisphere was, at a former period of the earth's history, much hotter than it is at present. The proofs of this are abundant. Shells and corals, discovered fossil in the secondary rocks, are found intimately connected, by generick affinity, with species now living in warmer latitudes. Turtles, tortoises and lizards, appear in great abundance in European formations; and plants have been found in situations, where they could not possibly have grown under the present temperature. Thus, in the superficial deposites of sand, gravel and loam, strewed over all parts of Europe, remains of extinct mammalia are discovered, among which are those of the elephant, rhinoceros, hippopotamus, bear, hyena, lion, tiger and others, consisting in a great measure of species now confined to warmer regions. In the elevated land of Europe, the rocks called secondary contain assemblages of organized fossils, all of unknown species, and many of them referable to genera now abundant between the tropicks. Among these, as we have seen, are gigantick reptiles, some of them herbivorous, others carnivorous, far exceeding in size any now known, even in the torrid zone. The genera are for the most part extinct, but some of them, as the crocodile and moniter, have still representatives in the warmer parts of the earth. Coral reefs were evidently numerous in the seas of the same periods, and composed of species, belonging to genera now characteristick of a tropical climate. In the ancient coal-deposites, the proofs are still more striking, for there we find equisitia upward

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of ten feet in height, arborescent ferns fifty feet high, and lycopodiaceæ from sixty to seventy feet; and these not only in Europe, but in North America and Greenland. These, together with the corals and chambered univalves which have been found at Melville island and other high latitudes, prove that during the carboniferous period, there was an elevated temperature, even in regions bordering on the arctick circle. The approximation to a climate similar to that now enjoyed in these latitudes, does not commence till the era of the tertiary formations, which, it will be recollected, are the latest formed of the stratified rocks.

To account for the change of climate thus indicated, some have argued for a derangement in the position of the earth's axis of rotation; but astronomers satisfactorily prove to us that this is impossible. Another theory we have already noticed, in treating of volcanoes, namely, the former thinness of the earth's crust, and the consequently greater amount of heat transmitted to the surface. Another, (but as we think,) a more improbable theory is, that the high temperature in northern regions, was the result of an arrangement of the land and sea, different from, and, indeed, the reverse of what now appears on the face of the globe. Wherever there are large tracts of land, with mountainous districts rising into the colder regions of the atmosphere, there will ice and snow be found to prevail and accumulate. But the ocean has a tendency everywhere to preserve a mean temperature, which it communicates to the adjoining land, so that it tempers the climate, moderating alike an excess of heat or cold. Accordingly, we find that the climate of islands is much more equable than that of continents. Their summers may be more cool, but their winters are warmer. If, therefore, the present relative positions

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of land and water were reversed, we may suppose, that in the islands, which would then occupy the polar regions, the temperature might be somewhat raised, by the prevailing mean temperature of the ocean—by currents flowing from the tropical regions—and by other favourable circumstances—so as, possibly, to render them fit for the support both of animals and plants, which could not exist in a climate such as is found at present in those quarters of the world. That such a distribution of land and sea *has* occurred, is not only possible, but highly probable; and the agents at present operating a change on the earth's surface, are quite competent to produce it again. "The imagination is apt to take alarm," says Mr. Lyell, whose theory is here presented, "when called upon to admit the formation of such irregularities on the crust of the earth, after it had once become the habitation of living creatures. But if time be allowed, the operation need not subvert the ordinary repose of nature; and the result is in a general view insignificant, if we consider how slightly the highest mountain-chains cause our globe to differ from a perfect sphere. Chimborazo, though it rises to more than twenty-one thousand feet above the sea, would be represented on a globe, six feet in diameter, by a grain of sand, less than one twentieth of an inch in thickness." It is claimed that the appearance of the whole system of stratified rocks, supports the theory which has been stated; but we shall only allude to a more recent series—the tertiary. In this formation, we find a gradual increase of animals and plants fitted for our present climates, in proportion as the strata which we examine are more modern; and it is an ascertained fact, that during all these successive tertiary periods, there has been a great increase of land in European latitudes. In fact, two thirds of the present lands in Eu-

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rope have emerged since the deposition of the earliest of these tertiary groups. Large portions of Sweden, Finland, Lapland, Turkey, France and Austria, the greater part of Prussia and Poland, the whole of Denmark, almost the whole of Russia, with part of England, have been elevated from beneath the ocean, during the period in question. The proofs of submergence are unequivocal, for the area described, is now covered by deposites, containing the fossil remains of animals, which could only have lived under water. The species, moreover, of the marine testacea, found in the *oldest* of these formations, cannot be deemed very remote, geologically speaking, for a proportion of more than three in a hundred of the fossils has been identified with species now living. The elevation, too, of the extensive districts mentioned, had been by no means sudden. Evidence has been obtained, which renders it probable, that there have been at least twelve different periods of elevation, affecting the strata of Europe.*

## THE DELUGE.

The proofs which we have just stated, of the elevation of land, naturally lead to the consideration of that most interesting portion of the Scripture history—the deluge. With the earlier geologists, this miraculous cataclysm was made the scape-goat on all occasions, when they were called upon to explain geological phenomena. According to them, the deluge levelled mountains and excavated valleys. They ascribed to it all the disruptions and contortions appearing in strata, and avowed that the shells discovered upon the loftiest mountains were depos-

* M. Elie de Beaumont.

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ited there by its waters. The argument derived from the shells is the most common, and the most easily controverted. Had these shells been left there by a flood, which lasted not many days, they would have been found upon the surface only, and not regularly distributed, but washed into heaps in the crevices and hollows. But this is not the case. They are found deposited regularly, and not on the surface merely, but in the deeply stratified beds, which form these mountainous masses, and must have taken ages to accumulate. They also occur in the same circumstances of quiet deposition, in which shells are found at present in the beds of our seas and rivers. Of course the natural and only rational hypothesis is, that these were deposited in the bed of the ocean; and were subsequently raised to their present elevation, along with the strata in which they are enclosed.

The theorists to whom we have alluded, point also to immense excavations of valleys, and portions of mountains rent and hollowed out, which, they say, were caused by the waters of the deluge. Such effects, if caused by water at all, (which we are far from admitting,) must have been affected by that element in a state of violent motion. There must have been the action of strong and unnatural forces of currents. But we are not entitled to suppose, that any such effects either accompanied the increase or the diminution of the waters of the deluge. In truth, until it can be explained in what manner the deluge was brought about, we are not entitled to ascribe to it any existing phenomena. We are not warranted to deduce conclusions where the premises are involved in obscurity.

Some geologists have supposed that that part only which was inhabited by man, and not the whole of the earth, was covered by the flood; but others

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reject this theory as inconsistent with the scriptural account, the terms of which are express, that "all the high hills that were under the whole heaven were covered." Besides, the contemplated destruction of life was intended to include the lower animals, which must have been distributed in various parts of the earth not occupied by man. We are expressly informed, accordingly, that "all flesh died that moved upon the earth, both of fowl and of cattle, and of beast, and every creeping thing."

On the supposition that the whole earth was covered, it appears to us that this must have been accomplished in one of two ways. It was effected either by the elevation of the bottom of the ocean, accompanied by a corresponding depression of the mountains, thus causing a level surface all over the earth, or by an accumulation of water, increasing till it covered the highest mountains, while the bed of the ocean and the surface of the earth remained unchanged. The *first* hypothesis is objectionable; 1st, because, in reference to natural causes, it is contrary to all reason and analogy; and 2d, because we have no evidence that the course of nature was departed from, in this particular way, in order to produce the effect. We are inclined, therefore, to adopt the *second* theory; because although contrary to the laws of nature, it is in accordance with the evidence furnished on Divine authority, that in a peculiar way those laws were departed from. "The flood," we are told, "was forty days upon the earth, and the waters *increased*." Again—"The waters prevailed and were increased greatly, and all the high hills that were under the whole heaven were covered. Fifteen cubits upward did the waters prevail, and the mountains were covered." This language is inconsistent with the idea of any mere change of surface, and express mention is made of

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an "increase" of water sufficient to cover the *then* elevated parts of the earth. If the cataclysm was caused by a change in the arrangement of strata producing a level, there would have been no occasion for an increase of water; neither would we have been told that the *high hills* were covered, or afterward, on the decrease of the waters, that "in the tenth month, in the first day of the month, were the *tops of the mountains* seen."*

But an interesting question immediately presents itself. Whence was derived this immense mass of water? The only answer is, We cannot tell. It did not come from the interiour of the earth; for we know that the mean density of our globe increases to the centre. Nor could it come from our own atmosphere. We agree with Mr. Lyell in regarding the deluge of Scripture as a great and peculiar catastrophe, accomplished by miraculous means, and not referable to any natural causes. It was easy for Him who says and it is done, to make use of other than natural instruments. He might have called waters from a thousand distant planets, and returned them to their source again, when the ends of his providence were accomplished.

There is abundant evidence in various parts of the world of repeated floods, and of some of them producing very great changes. But such changes are much more likely to have been produced by partial inundations, as the bursting of elevated lakes, or the effects of volcanoes and earthquakes, or otherwise, than by a universal deluge, when, as the waters rose gradually, so they would gradually and

† It is by no means certain, however, that the terms in Genesis are used in a strictly astronomical and universal sense, or that we are required to admit the entire universality of the flood over the whole face of the globe; and on this point, we believe, theologians are not agreed. *Am. Ed.*

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equally subside. It is the safest way on all occasions to refer natural phenomena to natural causes, particularly where, as in the present case, these are much more likely to have produced the effects spoken of.

## AGE OF THE WORLD.

There are some people, as already hinted, who, without bestowing on the subject the slightest study or attention, denounce the doctrines of geology as striking at the root of revelation. Such attacks were not so much to be wondered at in the earlier history of the science; because, till within a very late period, geology was nothing more than a collection of conflicting theories. Latterly a more philosophical spirit has prevailed, and geologists, by mutual consent, have exchanged the unprofitable employment of controversy for the more useful task of investigating facts. The result has been what might have been expected. More light has been thrown on the science during the present century than during the whole of its previous history, and although much remains to be done before a complete and accurate theory of the earth can be established, yet sufficient data have been acquired to demonstrate the untenable nature of many of the older dogmas. Of the inferences deduced from ascertained phenomena, one of the most important, and one on which all scientifick geologists are now at one, is, that the deposition of the older strata, and the introduction of animal and vegetable life upon the earth, must be assigned to a date long anterior to the creation of man; and in this conclusion we can see nothing repugnant to the literal terms of the Mosaick account.

"Those rocks," says Dr. Chalmers, "which stand



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forth in the order of their formation, and are each imprinted with their own peculiar fossil remains, have been termed the archives of nature, where she hath recorded the changes that have taken place in the history of the globe. They are made to serve the purpose of scrolls or inscriptions, in which one might read of those great steps and successions by which the earth has been brought to its present state. And should these archives of nature be but truly deciphered, we are not afraid of their being confronted with the archives of revelation. It is unmanly to blink the approach of light, from whatever quarter of observation it may fall upon us—and those are not the best friends of Christianity who feel either dislike or alarm when the torch of science or the torch of history is held up to the Bible. For ourselves, we are not afraid when the eye of an intrepid, if it be only of a sound philosophy, scrutinizes, however jealously, all its pages. We have no dread of any apprehended conflict between the doctrines of scripture and the discoveries of science, persuaded as we are, that whatever story the geologists of our day shall find to be engraved on the volume of nature, it will only the more accredit that story which is graven on the volume of revelation."*

Adopting as the basis of our investigation the principles thus soundly and eloquently laid down, let us inquire whether geologists have "truly deciphered" the archives of nature in assigning groups of rocks and genera of animals to a date long anterior to the period when man first became an inhabitant of this earth. It would occupy volumes to state in detail all the evidences derived from a study of the stratified rocks, by which we are compelled to come to an affirmative conclusion in this inquiry.

* Natural Theology, vol. i. p. 247.

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It may be observed in the outset, that in the absence of evidence to the contrary, we are bound to assume, that the same laws which govern nature now, are those by which she was governed a thousand or ten thousand years ago. This principle it is important to keep in view; because the advocates of limited duration assert, that the course of nature was altogether different a few thousand years ago from what it is at present, and that the action of the causes then in operation greatly exceeded in intensity the action of the same causes in our own day. On this assertion their theory hangs; for in no other way do they pretend to account for the phenomena exhibited in the crust of the globe. But the assertion is gratuitous—contrary to analogy—and not only unsupported by, but in direct opposition to, the evidence afforded by the phenomena themselves.

There are no series of rocks to which we can turn, where we shall not find striking proofs of the lapse of long periods of time. Let us compare, for example, the trifling extent of recent deposites of shells—not amounting perhaps to an inch or two in a century—with the extent of older deposites formed by the same means. The entire substance of some of the most extensive strata is composed of myriads of shells, among which the presence of countless multitudes of unbroken corallines and of fragile shells, having their most delicate spines still attached and undisturbed, shows that the animals which formed them lived and died on the spot, and that the stratum was formed not rapidly or suddenly, but by a slow and gradual process. The whole of the chalk formation, the average thickness of which has been estimated at one thousand feet, is entirely the result of marine shells, which, in the long course of ages, have been gradually consolidated with little intermixture of foreign matter; and the greater part

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of the limestone rocks is referable to a similar cause.

Thus "many extensive plains and massive mountains form, as it were, the great charnel-house of preceding generations, in which the petrified *exuviæ* of extinct races of animals and vegetables are piled into stupendous monuments of the operations of life and death during almost immeasurable periods of past time."*

Again, when we examine the shelly deposites of the tertiary formations, the results are equally conclusive. We have already had occasion to advert to the shells of these deposites, in speaking of the comparative age of rocks. We have seen that there are four distinct periods comprehended in the tertiary series, each distinguished by its own peculiar fossils, and evidencing the lapse of long periods of time between each formation; and that in Sicily, portions of the pliocene, or *latest* formation, rise in mountains to the height of two thousand feet. The most ancient records of history contain no notice of any important change in that country, far less of the elevation of such a mountain from the bed of the ocean; and there can be but one opinion, that, at least as early as the time of our first parents, it stood as it stands at present. But if to the age of these more recent strata, we add the eocene and miocene periods of the tertiary rocks—both which include extensive formations—and the whole of the secondary and transition rocks, including the coal-fields, the limestone, the sandstone and the slate; and add to all these, again, the time required for the deposition of the whole of the primary series, comprehending the immense masses of gneiss, and mica-slate, and quartz, and hornblende, and primary limestone, we will not believe that any one acquaint-

* Dr. Buckland. Bridgewater Treatise, vol. I. p. 112.

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ed with the first rudiments of the science will venture to affirm, that only six thousand years have elapsed since the earliest of these rocks was deposited.

The formation of the coal-series alone must have occupied a space of time, in comparison with which the date of man's creation is but as yesterday. A very sound geologist has calculated, that the coal-series of Newcastle, with its accompanying *strata*, must have required for its production a period of at least two hundred thousand years. But, supposing his calculation not to be sufficiently guarded, let us deduct a hundred thousand, or a hundred and fifty thousand years, and what a vast period still remains for *a single series of rocks*—a series forming but a small portion of the whole strata which compose the crust of the earth.

The same results follow the examination of every other formation; and when we observe in each the accumulation of the remains of animals and plants quietly reposing in the places where they lived and died—commencing with genera now wholly unknown, which again disappear, and are succeeded by genus after genus, each differing altogether from the other; while stratum, in like manner, succeeds stratum, and one series of rocks follows another series, all deposited, as the imbedded fossils prove, by a slow and regular process, similar in all respects to the formations going on under our own eye, we can come to no conclusion but this, that many thousands —it may be millions—of years have rolled over this planet since the commencement of the primary rocks. What the precise time is which has elapsed, it would be as idle to inquire, as it is impossible to tell, though no doubt every new discovery in the organick world will give additional light on the subject. It is evident that very long periods *have* elapsed.



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It now remains to inquire how the history thus deeply "engraven on the volume of nature," can be reconciled with that which is recorded by the inspired historian; to inquire, rather, whether *we* can reconcile it; for it would be presumptuous indeed to infer inconsistencies, because creatures with faculties so limited as ours cannot solve the difficulty—creatures who cannot explain our own constitution, nor account for one of ten thousand phenomena occurring daily before us in the present economy of the material world.

There are only two theories on this subject deserving any attention, According to the first of these, the "days" mentioned in the Mosaick account do not mean literal days of twenty-four hours, but successive ages of indefinite extent. The advocates of this opinion, among other arguments in support of it, refer to the succession of organick remains found in the different *strata*, as corresponding with the Mosaick account of the order of creation; but we do not think they are borne out by the facts. The following was the order of creation as it regards the organick world. 1. Trees and plants. 2. Fishes and birds. 3. Land animals, including reptiles and insects. 4. Man. Now according to the hypothesis stated, a long period must have elapsed during which the earth was covered with vegetation, but without any living creature existing upon it, or in the waters: for the plants were made on the third day, while the fishes and birds were not made until the fifth, nor the reptiles and insects till the sixth day. But in the transition rocks, where we find the earliest remains of vegetation, we also find the remains of sharks and other fishes of extinct genera, together with encrinites, sponges, and other marine animals. Again, reptiles and insects appear as early as the birds, or indeed, in older strata, whereas, ac-

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cording to the theory under notice, we should not find them till long afterward. And finally, according to the same theory, we should find the remains of man in the secondary rocks, for he was created in the same day with the reptiles; but in point of fact, no fossil remains of man have ever been found in any *strata*, even the latest, although his bones are as well fitted for preservation, as those of any other animal; and from his habits his remains would be even more likely to be found fossil than theirs—an unequivocal proof of his recent origin.

Besides all this, although it is true that the word translated "day," does in some parts of the Scriptures imply a long period of time, yet in the chapter before us, it cannot be so rendered without doing violence to the text. The expression, "the evening and the morning," as well as the subsequent appointment of one day in seven to be observed weekly—because "in six days" the Lord completed the work of creation—plainly limits the day to one of twenty-four hours.

The *other* theory referred to, which appears to come nearest the truth, assumes the six days to have been of the ordinary length; but holds that, subsequently to the formation of the earth, and *previously to the first day* of the Mosaick history, a long undefined period elapsed, during which all those strata were formed, and those plants and animals lived, of the existence of which, previously to our own epoch, there is such unequivocal evidence—and that the creation mentioned, as having been accomplished during the six days of scripture, was that of the plants and animals of our present system—a renewal, in short, of animal and vegetable life, and a preparation of the earth for the reception of man. If it be objected, that certain existing genera of plants and animals are analogous, and some species

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identical with those of the former systems; it may be answered, that in renewing and repeopling the earth, the Creator may have thought fit, for wise and good reasons, to observe the same order, and the same laws, which had existed in the antechaotick ages. Geology affords evidence, of not one, but many great revolutions, in which entire races have perished, and made way for others of different genera. But we generally find that the latter are, in many respects analogous to those which they have displaced, and the same law appears to have been observed in the last of these great renewals, with one prominent exception—namely, man.

This theory may, we conceive, be reconciled to the sacred history, without any violence to the original. We are not told that the heavens and the earth were created on the first day. The history says, that "*in the beginning* God created the heavens and the earth." This appears to be the grand announcement of the original creation, as distinct from the six days' work next described. The earth, in truth, is expressly recognised as *existing* in a particular state, *previous* to the first day:—"The earth *was* without form and void, and darkness was upon the face of the deep." We are therefore entitled to assume that a period did elapse between the creation of the earth and the *first day* of the Mosaick account. We are not told how long that period was. It may have been millions of ages, and may have witnessed thousands of successive creations. The Bible was given to us, only as a history of our own age. It was not designed to be a record of physical events at all; and if the natural phenomena of our present system are not explained, there is little wonder that we should be left without any information, except what is furnished by "the archives of nature," of events which happened long before. There is noth-

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ing then in the Scripture history inconsistent with the theory that animals and plants existed long prior to that chaotick state, which immediately preceded the work of the six days.

The principal difficulty occurs in the work of the fourth day, on which God is said to have "made two great lights, the greater light to rule the day, and the lesser light to rule the night;" because the existence of the luxuriant vegetation and various tribes of animals of the primordial world, implies the presence not only of light but of heat, both which must have come from the sun. But the difficulty will be found to lie mainly in the terms employed by the English translators, for the original is no way inconsistent with the idea of the previous existence of the sun and moon, but the contrary. The interpretation of the original as given by Rosenmuller—an able German commentator and critick—is very satisfactory: "This interpretation yields this literal sense in our language. 'Let the lights in the firmament of heaven for dividing between the day and the night, be for signs and for seasons, and for days and years; and let them be for lights in the firmament of heaven, to give light upon the earth: and it was so.'" Rosenmuller's induction from the construction of this passage, is, that the narrative in these verses respects the determination of the heavenly bodies, to the performance of some certain uses to the earth—not to the *production* of these bodies."*

The communication of light and heat to the earth from the sun, may have been suspended for a time by the intervention of clouds or thick vapour during the intermediate state of chaos, causing "darkness upon the face of the deep." "An incipient dispersion of these vapours may have readmitted light

* Chalmers' Natural Theology, vol. i. p. 254.

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to the earth upon the first day, whilst the exciting cause of light was still obscured; and the further purification of the atmosphere upon the fourth day, may have caused the sun, and moon, and stars, to reappear in the firmament of heaven, to assume their new relations to the newly modified earth, and to the human race."* The *creation* of these bodies is related in the first verse, "In the beginning God created *the heavens* and the earth," meaning etymologically the higher regions, all that seems above the earth and comprehending the siderial systems. And it would be contrary not only to the principles of astronomy, but to all reason and analogy, to suppose that previous to the fourth day the earth existed by itself in the regions of space, independent of the system of which it now forms a part, and before those countless hosts of suns and stars, forming other planetary systems, were called into existence.

These are some of the most prominent grounds on which it is conceived we are justified in holding the theory of the existence of creations previous to the days of our first parents, without impugning the sacred records. The reasoning may be erroneous, but that will not affect the facts pointed out by geology; it will merely add another illustration to a fact already well established—namely, the inability of finite minds to comprehend and reconcile the things of the Infinite. At the same time, the views which have been stated have the sanction of men whose opinions are entitled to the utmost weight. In addition to the authorities already quoted, we may observe that Bishop Gleig, though then sceptical as to the conclusions deduced from the fossil remains found in the ancient strata, yet admitted that "there is nothing in the sacred writings forbidding us to

† Dr. Buckland. Bridgewater Treatise, vol. i. p. 30.

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suppose that they are the ruins of a former earth."*

It has been asked what benefit did man derive from these great lapses of time, or why should the earth be allowed so long to continue the abode of plants only, or of inferiour animals? In answer to this question, a thousand instances of actual benefit might be cited; but it may be sufficient to remind the reader of the great advantage which we derive from coal, and lime, and other rocks, which were in course of formation during these primordial times. It may be objected, that God could have created these in a moment. True;—but was it not equally wise and right—more conducive to his own glory, and more calculated to excite in us feelings of reverence and admiration, that he should produce them by those slow but beautiful and simple processes, which we see still going on under our own eye, in the varied field of Nature. And what was the lapse of ages to Him, with whom a thousand years are as one day?

In conclusion, we cannot avoid quoting the words of another eminent authority—Professor Sedgwick—on this very interesting subject: "The Bible instructs us, that man and other living things have been placed but a few years upon the earth, and the physical monuments of the world bear witness to the same truth. If the astronomer tells us of myriads of worlds not spoken of in the sacred records, the geologist in like manner proves, (not by arguments from analogy, but by the incontrovertible evidence of physical phenomena,) that there were former conditions of our planet, separated from each other by vast intervals of time, during which man and the other creatures of his own date had not been called into being. Periods such as these be-

* Stackhouse's Bible by Bishop Gleig, 1816, pp. 6, 7.

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long not therefore to the moral history of our race, and come neither within the letter nor the spirit of revelation. Between the first creation of the earth, and that day in which it pleased God to place man upon it, who shall dare to define the interval? On this question, scripture is silent; but that silence destroys not the meaning of those physical monuments of his power, that God has put before our eyes, giving us, at the same time, faculties whereby we may interpret them and comprehend their meaning."

## ADDENDA

### TO THE NOTICE OF FOSSIL FISHES, pp. 31, 32.

SINCE this notice was written, Prof. Gale has obtained fossil fishes from the red sandstone rocks of New Jersey, in Morris county. A specimen now in hand apparently belongs to the genus *Palaeoniscus* of Agassiz, and appears to be identical with some of the specimens found in Connecticut.

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# ADVERTISEMENT

## TO THE FIRST AMERICAN EDITION.

The increasing interest with which the science of Geology is regarded by all classes of readers has induced the reprint of this compendium, which forms one of the series of useful little works known as the Glasgow Treatises. Several paragraphs and cuts have been added, for the purpose of illustrating American Geology, or new discoveries in the science. Few alterations have been found necessary in revising the text; but the theory of Mr. Lyell in regard to ancient climate, is now stated in a more guarded manner than was adopted by the author; this being, probably, the most doubtful of all the positions maintained by that eminent geologist.

EDITOR.

New York, July 30, 1838.

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